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Analysis of prospects of using solar energy in Russian Federation economy

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Abstract

On our planet, the hydrocarbon is limited thus inefficiency of hydropower engineering and ecological damage made by heat and nuclear power engineering make it extremely important to develop alternative energy sources, for instance solar one. This article provides volumes and tendencies of solar energy use taken from all the territories of Russia, analyses problems of substituting conventional types of energy for solar one. The authors made conclusions and defined prospects of developing solar energy in Russia.

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Keywords: Energy; Solar Energy; Prospects of Developing Solar Energy

1. Introduction

The power supply is one of the essential problems of human civilization. The level of economic welfare and social development of a society is largely determined by the level and type of energy consumed. All the processes of contemporary life, one way or another, are connected with necessity of energy use produced on an industrial scale.

The modern world dictates the need for scientific and technological research not only in the direction of technological improvements in the use of conventional energy resources (non-renewable fossil fuels - oil, natural gas, coal, uranium), but also in continuous search for the new sources of energy. This contributes to the exhaustion of non-renewable natural resources and environmental hazards of their consumption. The most disturbing consequence is the change of geological structures of the earth and environmental pollution by various industrial wastes, including radioactive wastes. The inevitability of constant increase in the costs of exploration and extraction of natural fuel resources, the complexity of the access to the new fields affect the importance of the shift to alternative energy sources.

The main conventional natural energy resource is oil - about a third of the world's total energy produced is at the expense of oil. The dynamics of oil production is characterized by a slowdown in production growth in the last decade (Fig. 1). This indicates the transition to the stage of saturation in the life cycle of the industry and of the limitations of the developed deposits.

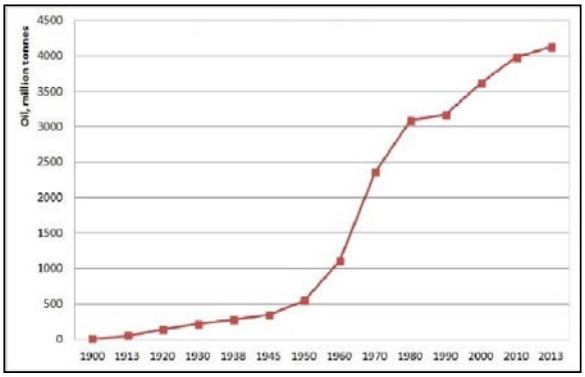

Fig. 1. The volume of oil production in the World, 1900 - 2013. [1]

A similar pattern exists in the Russian Federation. Oil production had been falling in 90th, due to the structural reform of the economy - the transition from the Soviet planned system to a market mechanism does not change the general trend towards the stabilization of oil production (Fig. 2).

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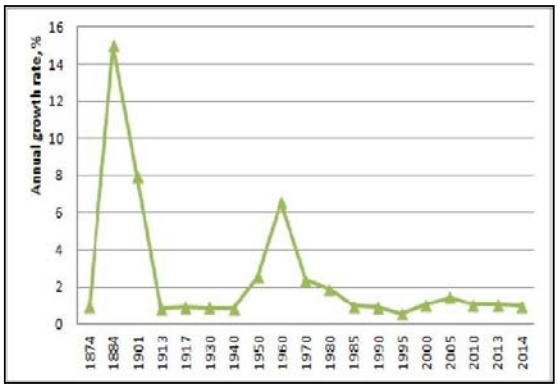


Fig. 2. The volume of oil production in Russia, 1874 - 2014. Calculated by [1].

Therefore, now more and more attention paid to issues related to the possibility of obtaining energy from renewable, natural unlimited and environmentally friendly sources. The formation of the renewable energy industry is the problem that every modern state is trying to solve somehow.

Russia is the largest country in the world by area and is one of the leading powers in population, and it is always in need of its own highly developed energy sector, which can ensure a stable supply of the state's economy. The presence of significant reserves of natural fuel resources (Russia contains on its territory 45% of the world's natural gas reserves, 23% - coal, 14% - uranium, 13% - oil) identified the main development of the energy industry. Of course, such a rich natural reserves can ensure the long-standing "comfortable life" (self-supporting with the necessary amount of energy). However, actual use does not match the existing needs. The power supply in Russian territory-administrative units differs regionally from one another because Russian Federation unites very different geo-climatic, industrial consumer characteristics. Currently about 25 million people live in areas of off-grid or unreliable centralized power, occupying more than 70% of the territory of Russia [2]. In addition, there is more serious environmental problems related to emissions of hazardous substances (wastes of conventional energy consumprion) into the atmosphere, soil, water pools. The "environmental" diseases of the population and the threats associated with impaired functioning of nuclear power stations (such as Chernobyl (Ukraine) and Fukushima (Japan) nuclear power plants) are spreading.

The imbalance of power supply in Russian regions, together with the environmental hazards of exploitation of conventional energy resources led to increased attention to alternative sources of energy at all levels, from national to private consumers.

As an alternative (renewable) energy sources are seen «sources on the basis of existing or constantly recurring processes in nature, as well as the life cycle of plant and animal life and the life of human society» [3, 4]. These include the thermal energy of the earth's interior, wind energy, solar energy and cosmic energy (the energy of the orbital motion of the planets). In contrast to the limited natural fuel resources, alternative sources are inexhaustible – the possibility of their use is boundless in time, at least within the life cycle of our planet. In addition, the production of heat and electricity in power plants that employs renewable resources significantly is greener than conventional power plants.

2. Trends of solar energy in the world

First place among the alternative sources of energy, of course, belongs to the sun. Solar radiation provides solar and thermal energy. It provides the electrical and solar heating systems, transformers scattered low-grade thermal energy, converted thermal energy for hydraulic installations, the kinetic energy for wind and wave installations, energy for photosynthesis, plants for processing of biomass. Let us dwell on the actual use of solar power the energy potential is many times greater than the energy needs. Famous Russian physicist and Nobel Prize winner, academician Zhores Alferov believes that "a bet on solar energy should be viewed not only as a win-win, but in the long run and uncontested choice for humanity" [5].

The recognition of solar energy industry of the future can be confirmed by the dynamics of the number of working stations and volume of the produced energy in the world practice (Fig. 3). Solar power plants that operate in the world can satisfy the domestic needs of 70 million people, with an average European level of consumption [6].

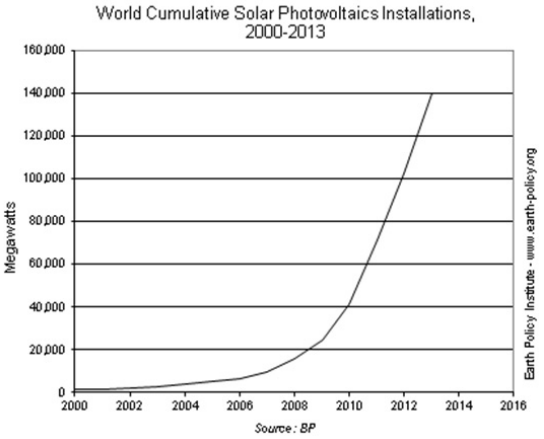


Fig. 3. Worldwide capacity of photovoltaic systems, 2000-2013. [7]

The market is growing by more than 40% per year, and falling prices for solar panels, make solar energy more accessible [6]. On the leading position among the manufacturers of the equipment required is China. The leader in the field of solar power is Germany. The share of the country accounts for about a third of the solar energy produced in the world [8].

The development of ways of converting solar energy into electrical energy is accomplishing in two ways: firstly, based on the photoelectric effect, and secondly, using photo thermal technology.

In the first direction, several generations of solar cells can be distinguished: mono-crystalline silicon (the most actively used at the workplace and at home, mainly on the Russian market); epitaxial semiconductor battery (thin film, the main purpose of space projects); solar cells created using nanotechnology (advanced development, with substantially higher coefficient of performance).

The photo thermal technology provides coherent conversion of solar energy into heat and then into electricity. The first electric solar power station in Russia (then was the USSR) was based on the application of geothermal technology with the water used as coolant. It was built in 1985 and has been using in operation for about six years, it generated about 2 million kWh of electricity.

3. Prospects for the development of solar energy in Russia

The assessment of the energy potential resource of solar power in the territory is necessary for practical applications of solar energy. Similar studies are conducted in the Russian Federation since 1920s. Today, Russian science has data to determine the effectiveness of solar energy in various regions of the country [3, 9, 10]. North Caucasus, Black Sea region and Caspian Sea, Southern Siberia and Far East have the greatest solar energy potential (Fig. 4). Promising regions for the use of solar energy are in the south-western area: Kalmykia, Stavropol region, Rostov region, Krasnodar region, Volgograd region, Astrakhan region and in the south-east of the country: Altai, Primorye, Zabaykalsky Kray, Buryatia. In addition, the level of insolation in some areas of Western and Eastern Siberia, the Far East is superior to that index of the southern regions.

Fig. 4. The solar energy potential in Russia (the level of insolation, kWh/m2/per day). [12]

According to official Russian statistics, the three largest federal districts: Privolzhsky, Siberian and Urals federal districts, that cover 46% of the Russian territory and include 42% of the population (Fig. 5), are regions where the amount of energy consumed is greater than the volume of energy produced [11].

A study of insolation in these regions shows that they have the most potential in terms of implementation and development of solar plants as a possible source of uninterrupted and adequate supply electricity.

Fig. 5. Federal District of the Russian Federation.

4. Methodology of the research

The research of prospects of the development of solar energy in the region is impossible without a statistical analysis of its energy supply. The portfolio analysis can be used as a tool for spatial and dynamic analysis of energy supply in the region.

The portfolio analysis is a tool typology of socio-economic processes for the management decisions [13, 14, 15, 16].

The methodology and algorithm implementation of portfolio analysis repeats the idea of the typological groups. The use of these methods is divided into a number of interrelated steps: determination of the object of study, formulation of the problem, basting types, selection of grouping characteristics, determining the intervals of the partition, the grouping method, the amount actually received type, the presentation of results in as graphic images. Portfolio analysis is used by Western companies since 1950s. It is increasingly used in the Russian practice in recent years. The portfolio analysis is the tool by virtue of which the company management evaluates different types of production and lines of business activity for the purpose of determination the most effective ones on the basis of application of specifically elaborated normative strategies. The advantages of the portfolio analysis are compact and visual image of positions and business challenges; simplicity and availability; the emphases on the qualitative parts of the analysis; capability of immediate implementation of the results [15, 17, 18].

The authors constructed an adapted matrix BCG for the determining the prospects of the energy supply of the Federal Districts of the Russian Federation by using traditional energy sources.

The official data of the Federal State Statistics Service (Rosstat) for 2012-2013 were used to construct the matrix. The data for these calculations are presented in Table 1.

The horizontal axis values (X-axis of matrix) are located the level of energy supply of the Federal Districts (the ratio of generated and consumed energy), the vertical axis (Y-axis) -

the rate of increase of electricity production in the region (it means a growth potential of power supply).

Table 1. Production and consumption of electricity in the Federal Districts of Russia in 2012-2013.

Federal District of Russia	Production in 2012, billion kWh	Production in 2013, billion kWh	Consumption in 2013, billion kWh	The ratio of generated and consumed electricity in 2013	The rate of increase of electricity production in 2013 compared to 2012, %	Electricity consumption per capita in 2013, mln kWh
1. Central Federal District	235,8	227,5	217,4	1,047	-3,5	5,6
2. Southern Federal District	55,8	60,6	62,5	0,971	8,7	4,5
3. North-West Federal District	114,4	111,0	107,8	1,030	-2,9	7,8
4. Far Eastern Federal District	49,0	49,8	45,5	1,095	1,7	7,3
5. Siberian Federal District	212,7	209,3	221,6	0,945	-1,6	11,5
6. Ural Federal District	184,7	183,1	185,2	0,988	-0,9	15,1
7. Privolzhsky Federal District	192,8	195,0	198,0	0,985	1,2	6,7
8. North Caucasian Federal District	24,3	22,9	23,3	0,984	-5,8	2,4

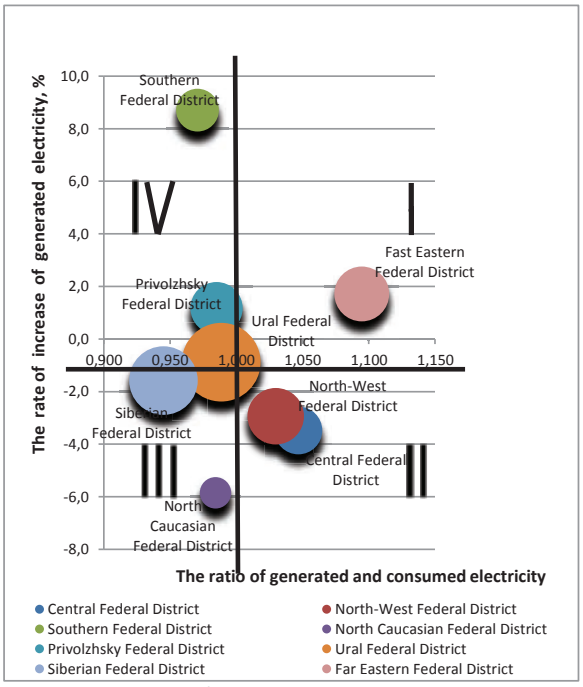
The critical point of transition from one type to another on the horizontal axis is 1, when there is a complete power supply in the district; the critical transition point on the vertical axis is the rate of increase of electricity generated in Russia in 2013 (-0.94%). The electricity consumption per capita is used as the area of a circle in the proposed system of coordinates.

5. Results of the research

The matrix made it possible to identify four types of Federal Districts by level of energy supply (Fig. 6):

I. Districts - donors. There is a complete energy supply and growth rates above the national average;

Fig. 6. Portfolio analysis matrix of Federal Districts of the Russian Federation in the coordinates "The ratio of generated and consumed electricity – The rate of increase of generated electricity"*. Calculated by [11].



II. Districts - recipients. This type is characterized by the total energy supply, with low growth or decline of power generation;

III. Depressive districts. They correspond to the lack of energy supply (less than 1) and correspond to growth rates below the national average;

IV. Districts of growth, characterized by a lack of power supply, but the growth rate of power generation are higher than the Russian average.

Each type has its own prospects for the development solar energy.

Federal districts were distributed by the sectors of the matrix. The analysis of the matrix helps to assess the level of energy supply of federal districts, identify prospects, creates an opportunity to develop a strategy for the development of the districts increase the energy supply.

The group of donors includes only from Far Eastern Federal District, the group of growth includes Southern and Privolzhsky Federal Districts. These are the main producers of conventional electricity. The group of recipients is a special group (Central and North-West Federal District). They are provided with energy from their own and the redistribution of energy resources. The most promising districts, which can and must develop solar energy - are the federal districts, which

* The analysis does not take into account data on the newly created Crimean Federal District.

formed the depressed group (Siberian, Ural and North Caucasian Federal District).

The fact that the Siberian and Far Eastern territories are characterized by low population density makes it apparent that the presence of local, uninterrupted and independent electrical power sources is an essential requirement for the power supply system. Therefore, the promotion of individual systems with the sale of surplus energy to the central grid is economically more reasonable than the construction of large objects of conventional energy. Expansion of the scope of the regional solar energy will be carried out primarily at the expense of private users.

According to various estimates, the total amount of installed capacity of solar generation in Russia is not more than 5 MW at present, most of which falls on individuals. The solar power plant in the Belgorod region put in place in 2010 and it is the largest industrial facility in the Russian solar energy, whose power is 100 kW. Russia has advanced technology to convert solar energy into electricity. However, the solar power system is represented mainly by small projects based on the use of photovoltaic silicon cells.

In recent years, governments in Russia are increasingly focused on renewable energy. Adopted in 2009, "Energy Strategy of Russia until 2030" defines an "increase in the relative volume of production and consumption of electricity from renewable energy sources (excluding hydro power plants with installed capacity of over 25 MW) from about 0.5 to 4.5 percent" as one of the major problems [19]. In 2013, the Government of the Russian Federation adopted a separate resolution on the need for state financial support generators of energy from alternative sources. In order to implement this resolution to select the recipients of state support commercial operator of the Russian wholesale electricity market - Open Society "ATS" - annually conducts a competitive selection of investment projects for the construction of generating facilities that operate on the basis of renewable energy sources. The following conditions are set for the project: localizing the production of equipment used (for solar stations - 50-70%), limiting the capital costs, the period of construction of the station before entering into force should not be more than 4 years [20]. The degree of performance targets for the number of successful applications in 2014 was only 29%; for 2015 it is planned even less, at 18%. Unfortunately, the strict requirements largely limits the access of small and medium businesses to participate in the state program.

In 2014, the Government of the Russian Federation Deputy Prime Minister A. Dvorkovich was assigned an additional functionality to coordinate and support the implementation of programs for renewable energy. Thus, we can expect a decisions for many issues in the industrial promotion of alternative energy sources.

6. Conclusion

In general it can be noted that the undeveloped technical and legal framework, as well as insufficient equipment required for economical and efficient production of electricity hinders the development of alternative energy in the Russian Federation. The development of alternative energy is very important goal in the depressed, energy-deficient regions, also in regions with high insolation.

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